

Table B.1
Total Factor Productivity Growth

	PERIOD GROWTH RATE
US INDUSTRY	
BLS: 1948-1992	1.3%
APC: 1948-1987	1.7%
JGF: 1948-1979	0.8%
LRC(2): 1952-1987	1.2%
COMMUNICATIONS INDUSTRY	
APC: 1948-1987	4.0%
AT&T: 1947-79	3.2%
LRC(1): 1947-1979	3.2%
LRC(2): 1951-1987	3.2%
RWC: 1960-1987	3.4%
JGF: 1948-1979	2.9%
LRC(3): 1984-1992	2.6%

- (1) BLS: Bureau of Labor Statistics, Multiproduct TFP Growth, U.S. Private Business.
- (2) APC: American Productivity Center, Multiproduct TFP Growth, U.S. Private Business, Communications Industry.
- (3) JGF: Dale W. Jorgenson, F. M. Gollup, and B. M. Fraumeni, *Productivity and U.S. Economic Growth* (Cambridge: Harvard University Press, 1987).
- (4) LRC(1): L. R. Christensen, Testimony filed in *United States v. AT&T*, Civ. Action No. 74-1698 (D.D.C. filed November 20, 1974).
- (5) AT&T: *Bell System Productivity Study: 1947-1979* (September, 1980).
- (6) LRC(2): L. R. Christensen, "Total Productivity Growth in the U.S. Telecommunications Industry and the U.S. Economy: 1951-1987," filed in North Dakota Public Service Commission Case No. PU-2320-90-149 (October 1, 1990).
- (7) RWC: R. W. Crandall and J. Galst, "Productivity Growth in the U.S. Telecommunications Sector: The Impact of the AT&T Divestiture," The Brookings Institution (July, 1990).
- (8) LRC(3): L. R. Christensen, Philip E. Schoech, and Mark Meitzen, "Productivity of The Local Operating Telephone Companies Subject to Price Cap Regulation" Filed as Attachment 6 behalf of USTA in CC Docket 94-1 (May 3, 1994).

Table B.2
TFP Differential
U.S. Industry and Telecommunications

	GROWTH RATE DIFFERENTIAL
1947-76: Nadiri-Schankerman ⁽¹⁾	2.1%
1948-79: JGF ⁽²⁾	2.1%
1948-79: LRC(1) ⁽³⁾	1.6%
1948-79: AT&T ⁽⁴⁾	2.0%
1948-87: APC	2.3%
1951-87: LRC(2)	1.9%
1960-87: RWC	2.2%
1963-91: DRI ⁽⁵⁾	2.8%
1984-1992: LRC(3)	2.3%

- (1) M. J. Nadiri and M. Schankerman, "The Structure of Production, Technological Change, and the Rate of Growth of Total Factor Productivity in the U.S. Bell System," in *Productivity Measurement in Regulated Industries*, T. Cowing and R. Stevenson, eds. (New York: Academic Press, 1981).
- (2) D. W. Jorgenson, "Productivity and Postwar U.S. Economic Growth," *The Journal of Economic Perspectives* (Fall, 1988), citing D. W. Jorgenson, F. M. Gollop, and B. M. Fraumeni, *Productivity and U.S. Economic Growth* (Cambridge: Harvard University Press, 1987).
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- (5) DRI/McGraw-Hill, *Pennsylvania Telecommunications Infrastructure Study*, Volume V (March 1993).
- (6) LRC(3): L. R. Christensen, Philip E. Schotch, and Mark Meitzen, "Productivity of the Local Operating Telephone Companies Subject to Price Cap Regulation," filed as Attachment 6 on behalf of USTA in CC Docket 94-1 (May 3, 1994).

Table B.3
Productivity Differentials
Based on Output Price Changes

CPI-U - CPI-TELEPHONE	AVERAGE ANNUAL GROWTH
1935-1985 ⁽¹⁾	1.95%
1975-1985 ⁽¹⁾	2.64%
1937-1987 ⁽²⁾	1.8%
1977-1987 ⁽²⁾	2.0%
1942-1993	2.0%
1982-1993	1.5%
1959-1993 ⁽³⁾	2.4%
1929-1993 ⁽⁴⁾	1.6%
1946-1993 ⁽⁴⁾	1.8%
GNP-PI - CPI-TELEPHONE	
1959-1993 ⁽⁵⁾	1.7%
1982-1993 ⁽⁶⁾	1.5%

(1) J. L. Lande and P. L. Wynns, "Primer and Sourcebook on Telephone Price Indexes and Rate Levels," Industry Analysis Division, Common Carrier Bureau, Federal Communications Commission (April, 1987).

(2) "Trends in Telephone Service," Industry Analysis Division, Common Carrier Bureau, Federal Communications Commission (August 1, 1988).

(3) This period, for comparison purposes, matches the period for the first GNP-PI differential below.

(4) Data from FCC, Supplemental Notice of Proposed Rulemaking, CC Docket 87-313 (March 12, 1990), Appendix D: T. Spavins and J. Lande, "Total Telephone Productivity in the Pre and Post-Divestiture Periods," updated through 1993. The original study found differentials of 1.7% for 1929-1989 and 2.0% for 1946-1989.

(5) The longest period for which GNP-PI data is available.

(6) Compare with CPI-U number over the same period above.

Figure B.1
U.S. TFP 10 Year Moving Average
Generally Varies Between 1 and 3 Percent

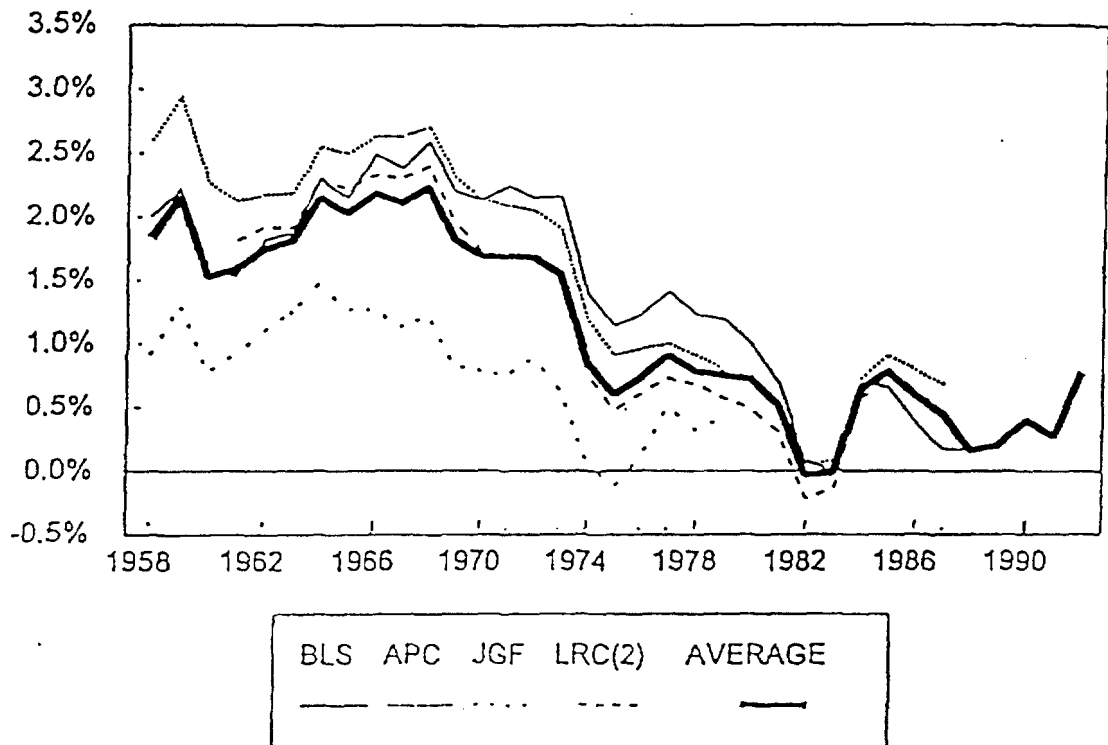


Figure D.2
Telecommunications TFP 10 Year Moving Average
Generally Varies Between 2 and 5 Percent

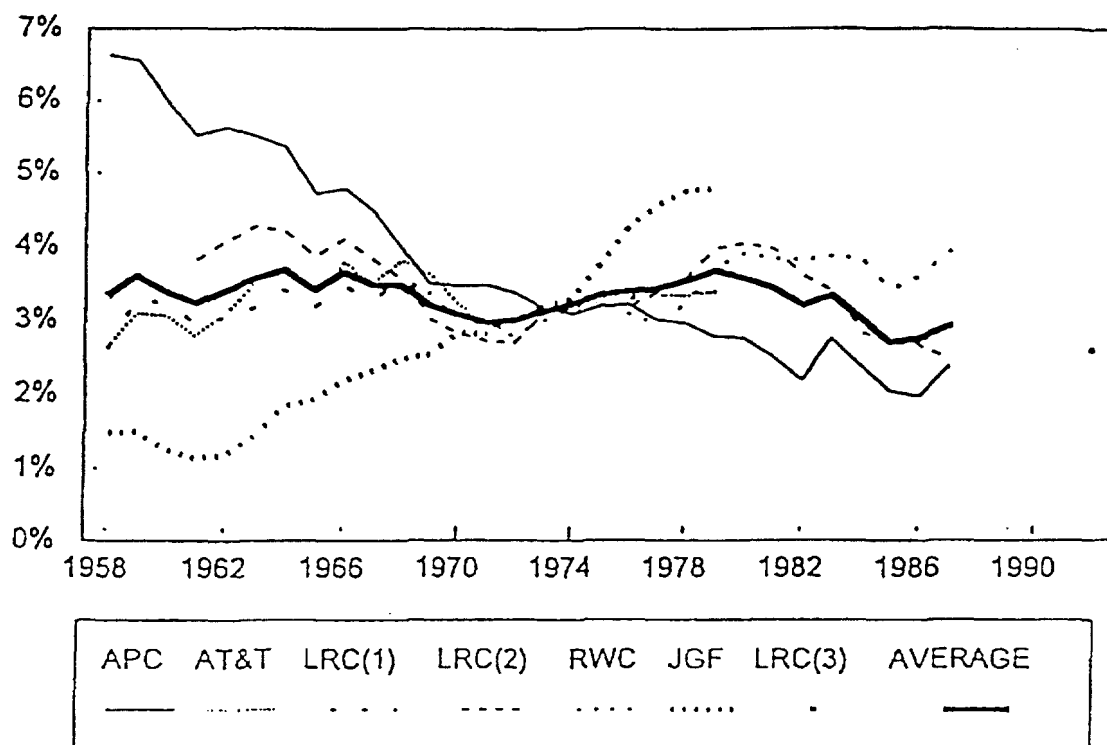


Figure B.3
Telecom TFP 10 Year Moving Average Minus
U.S. TFP 10 Year Moving Average Varies Between 1 and 3 Percent

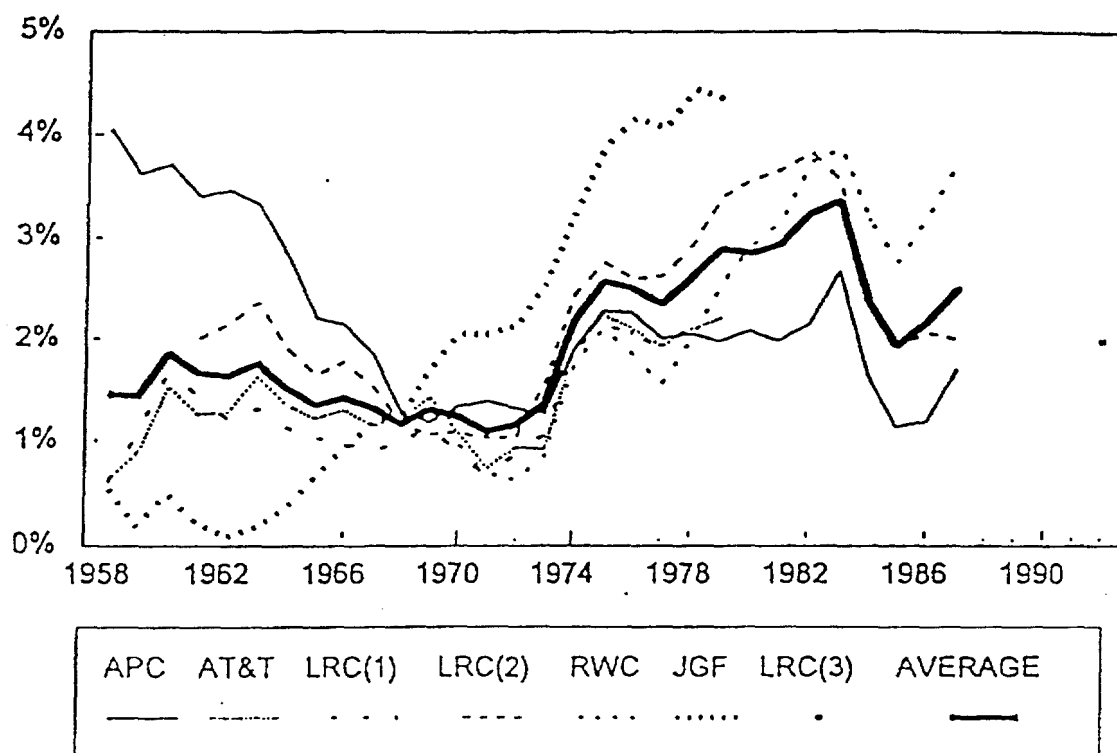


Figure B.4
Long Run Annual Productivity Offset
CPI-U All Commodities - CPI-U Total Telephone

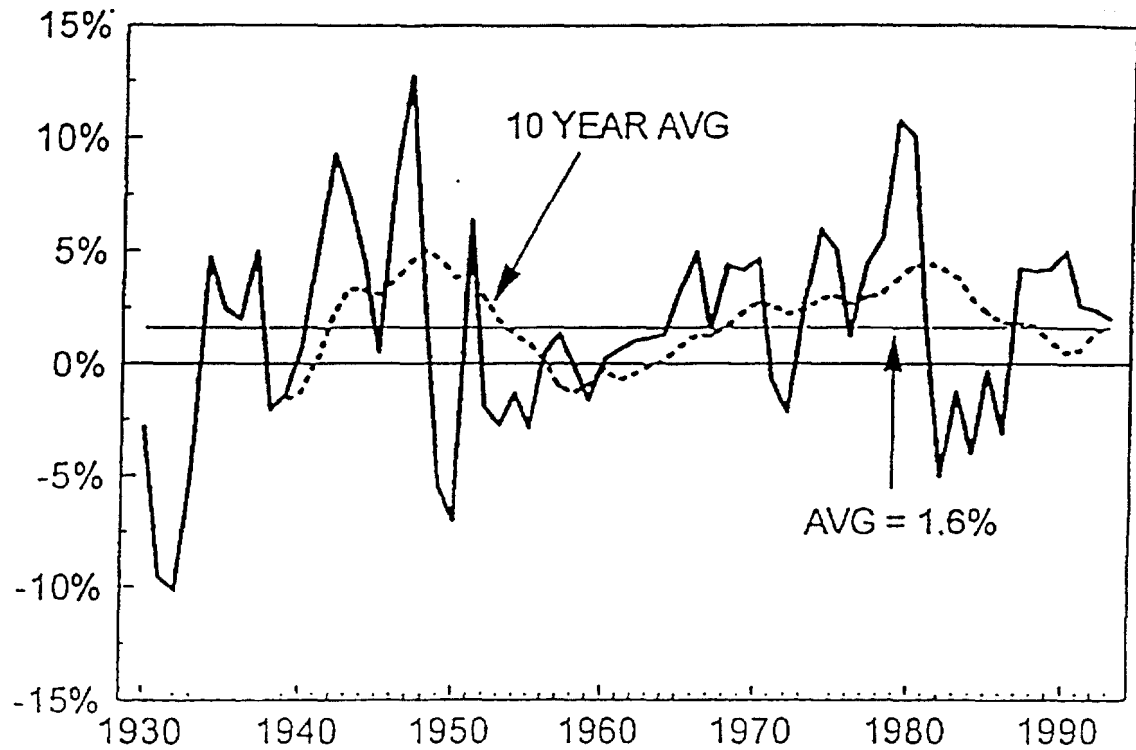


Figure B.5
Long Run Productivity Offset
GNP-PI - CPI-U Total Telephone

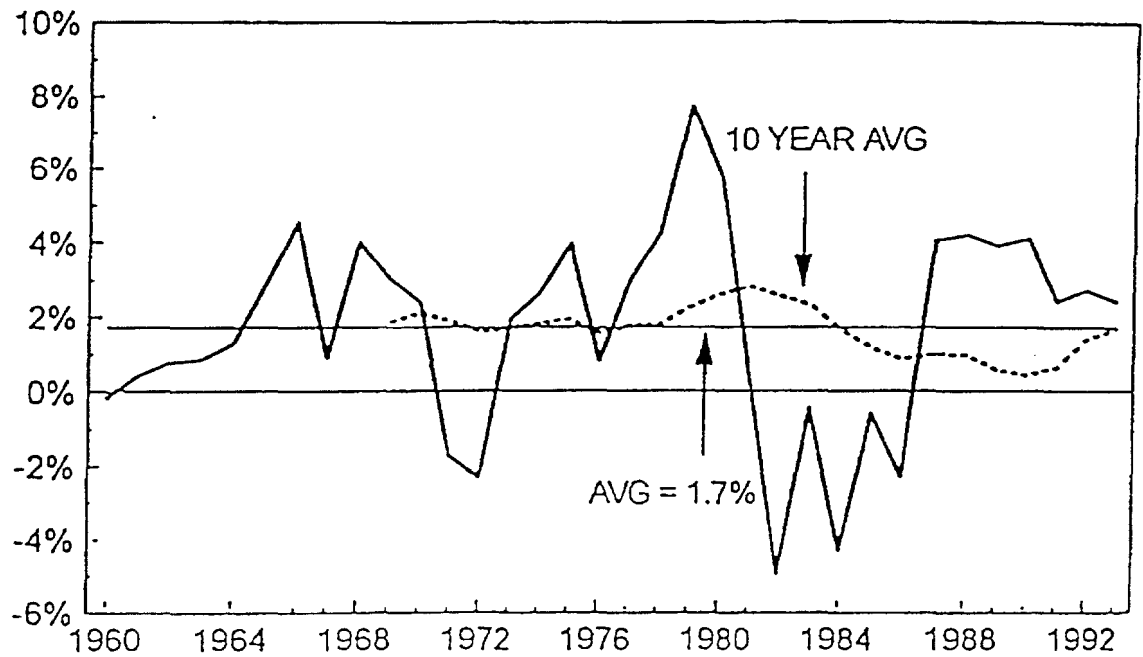


Figure B.6
Long Run Productivity Offsets
for Local Telephone Companies

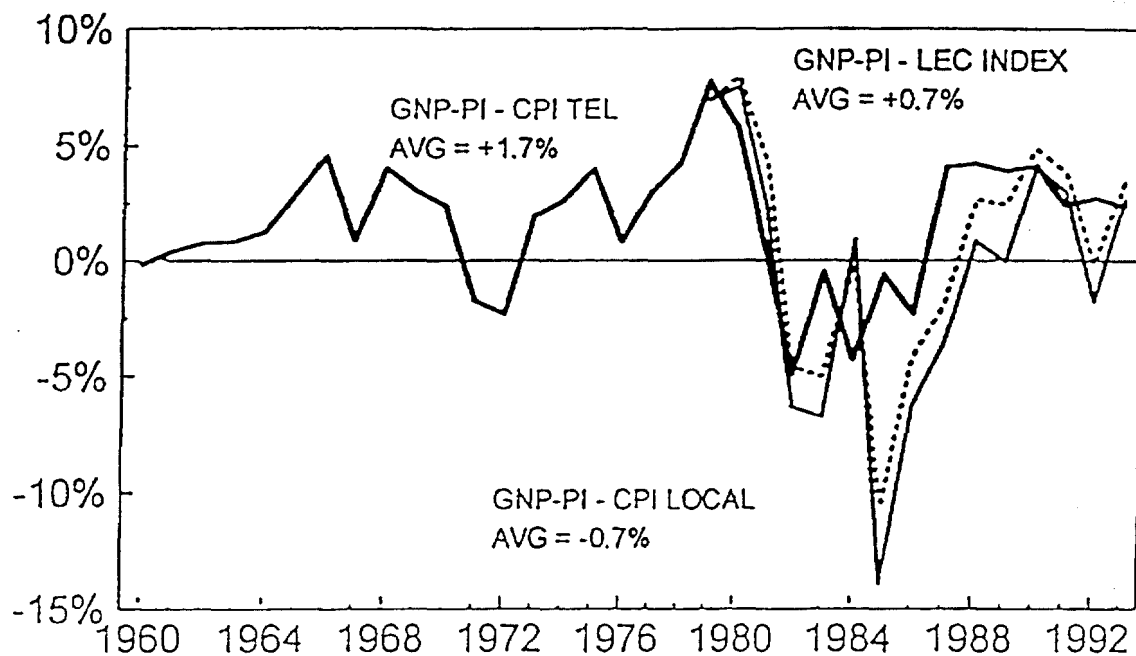


Figure B.7
U.S. Private Business TFP Growth

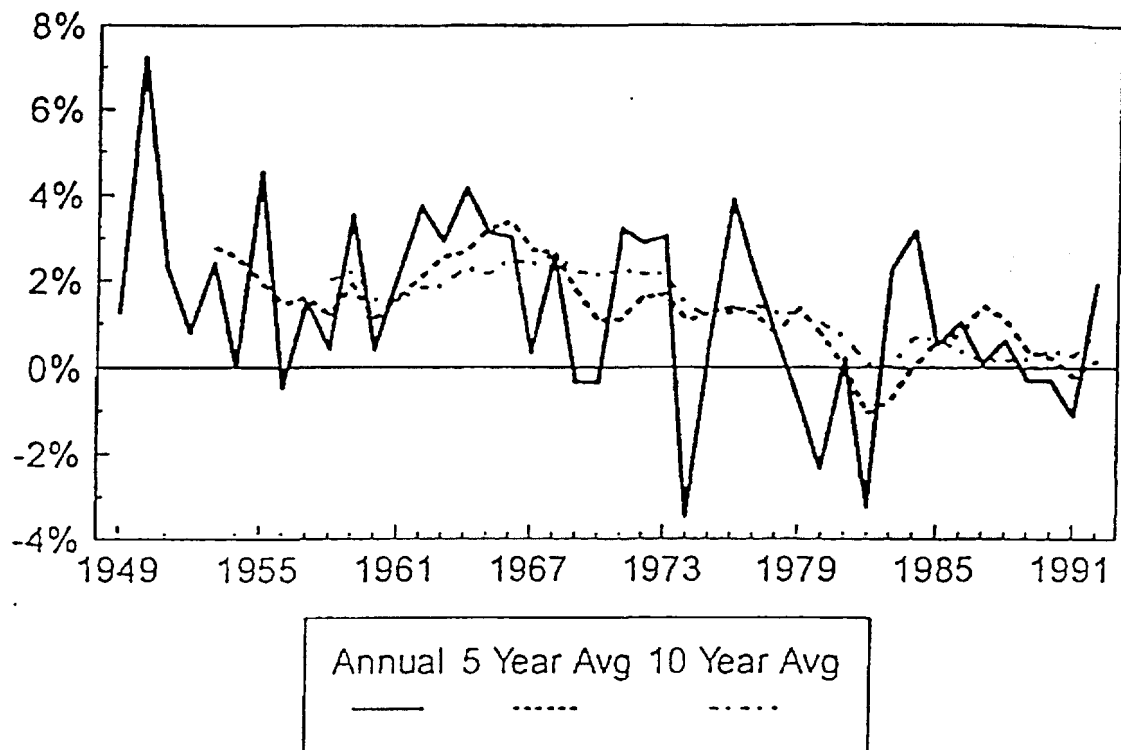


Figure B.9
Differences in Annual TFP Growth
Telecommunications - U.S. Private Business

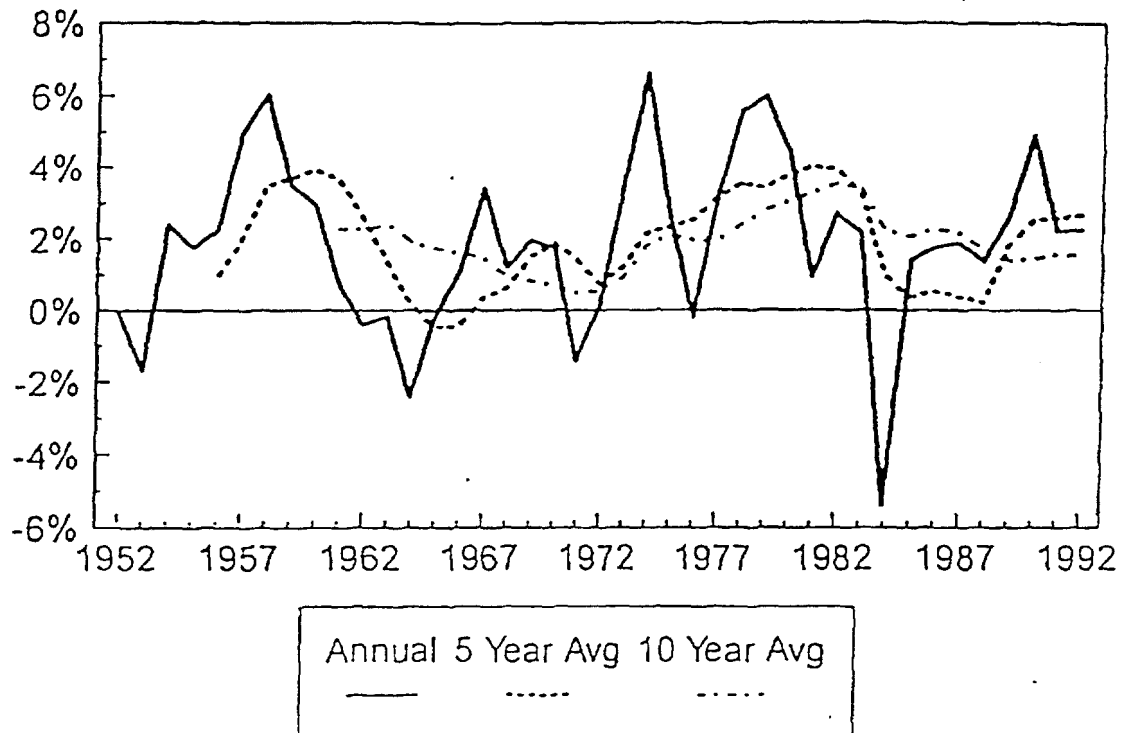


Figure B.8
Telecommunications Industry TFP Growth

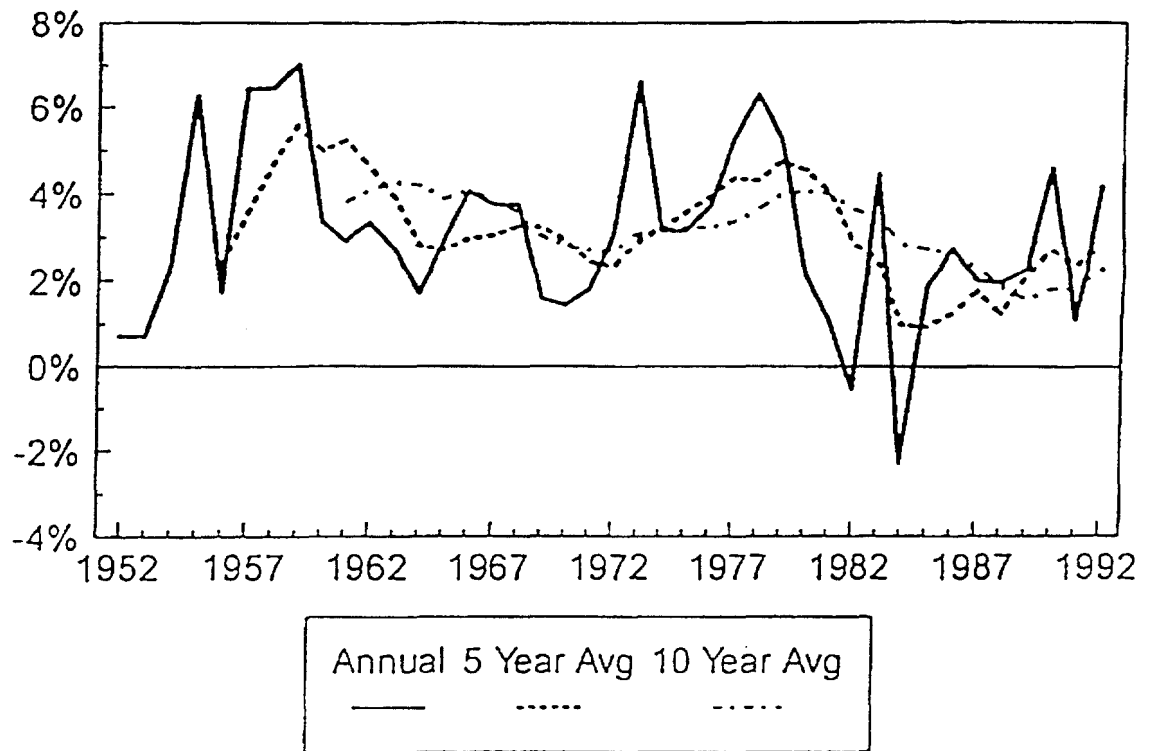
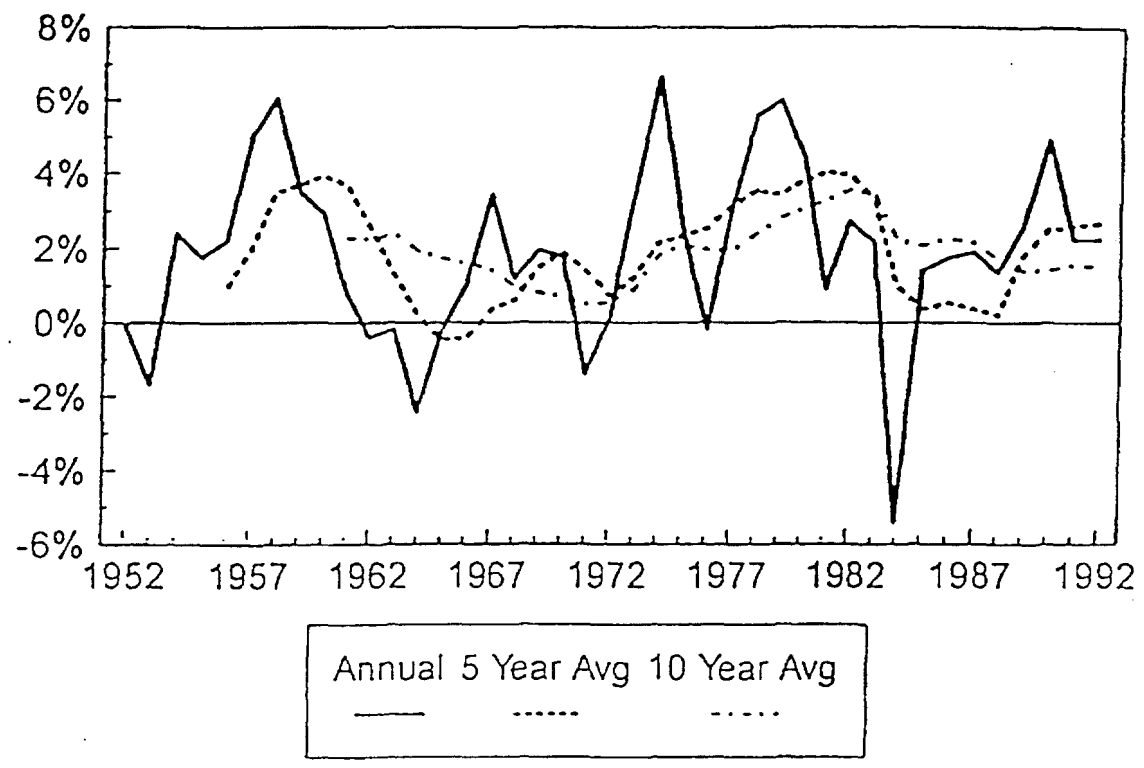


Figure B.9
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is about 3 years.¹ For statistical purposes then, a 3 year period (a complete cycle) should be treated as a single observation, and multiple 3 year periods--i.e., a minimum of 6 years--must be observed to calculate a meaningful average productivity measure with any degree of precision.

This requirement, coupled with the need to average out the effects of a single company's erratic changes in TFP, require that a large sample of the telecommunications industry is reviewed over a long period of time. Figure B.8 shows annual and five and ten year averages of telecommunications TFP growth. Finally, it is only the difference between national and industry TFP growth that matters for the productivity target in the price cap formula. Figure B.9 shows considerable variation in annual productivity differences, ranging from +6.6 to -5.4 percent per year. The differences in the ten-year moving average are much less extreme ranging from a maximum of +3.5 and a minimum of 0.5 percent.

The picture in Figure B.9 also shows clearly that the long-run productivity differential between the U.S. telephone industry and U.S. private business averages about 2 percent per year. We observed this same fact earlier in Figure B.5, where we noted that the difference between the annual rate of growth of GNP-PI and the CPI-U total telephone price index was 1.7 percent.² This same differential (approximately 2 percent) has been observed by most students of telecommunications productivity; possibly its strongest statement was provided by the FCC staff

¹ Thus annual growth in TFP rises and falls more rapidly than annual growth in GNP, averaging about 3 years between peaks or between troughs. J. W. Kendrick, *Long Term Economic Growth 1860-1970* (Washington D.C.: U.S. Bureau of the Census, June 1973).

² An important duality principle in the economic theory of production assures us that we can use relative growth rates of input and output prices or quantities to estimate relative growth rates in TFP. See, for example, D. W. Jorgenson, "The Embodiment Hypothesis," *The Journal of Political Economy* (February 1966), pp. 1-17.

in the federal price cap docket where they noted a constant productivity differential (using output prices) of between 1.7 and 2 percent over the 1929-1989 period.³

These results suggest that the price cap would be too volatile to be practical, if the productivity target were adjusted every year based on annual productivity growth. Moreover, if a company's own productivity growth were used to establish the productivity target, the incentive basis of the price cap formula would degenerate. A plan in which a company's TFP growth this year determines its price growth next year would be perilously close to ordinary rate of return regulation based on an historic test year. To obtain the full benefit of incentives to increase productivity growth and achieve the highest possible dynamic efficiency, the productivity target must be *fixed* (i.e., constant over time), so that the firm will treat it as independent of any of its actions.

E. A 2 Percent Differential is Consistent with the FCC Productivity Target

Our historical TFP differential is consistent with the productivity target used by the FCC in its price cap plan for local exchange carrier interstate services. The FCC has implemented a productivity offset of 3 percent in its price regulation plan for AT&T and 3.3 percent for its price regulation plan for the interstate access services of the LECs. (A LEC may

³ Supplemental Notice of Proposed Rulemaking, CC Docket 87-313 (released March 12, 1990), Appendix D, "Total Telephone Productivity in the Pre and Post Divestiture Periods," by T. C. Spavins and J. M. Lande; and Second Report and Order, CC Docket 87-313 (released October 4, 1990), Appendix D, "The Long Term View of the Appropriate Productivity Factor for Interstate Exchange Access," by T. C. Spavins.

select a productivity offset of 4.3 percent in exchange for a more favorable sharing proportion for earnings above 12.25 percent.) The FCC's adoption of 3 percent as a productivity offset for AT&T derives primarily from its analysis of AT&T's post-divestiture output prices (Further Notice of Proposed Rulemaking, CC Docket 87-313, released May 23, 1988, Appendix C), in which AT&T's MTS prices were shown to have grown approximately 2.48 percent more slowly than the GNP-PI over the post-divestiture period. An explicit "consumer productivity dividend" of 0.5 percent was added to the historical AT&T productivity differential to insure that ratepayers benefitted from the regulatory change.

The productivity offset of 3.3 percent for LECs in the price cap plan reflects several factors which do not apply to intrastate service. First, interstate demand is almost entirely driven by toll traffic and growth in interstate toll traffic, stimulated by lower toll rates, is significantly greater than the growth of intrastate toll or local service. Second, the 3.3 percent offset is specific to the LEC price cap plan, and its value is very sensitive to details such as the treatment of common line demand in the price cap formula. Finally, Appendix D to the Second Report and Order in CC Docket 87-313 showed that a long run productivity differential for the total industry of 1.7 to 2.0 percent would imply an interstate productivity differential of 2.1 to 2.6 percent and an associated intrastate productivity differential of 1.57 to 1.81 percent: T. C. Spavins, "The Long Term View of the Appropriate Productivity Factor for Interstate Exchange Access," pp. 9-10.

F. Conclusion

Based on this review of twenty direct and indirect productivity studies, it is clear that on average, telecommunications total factor productivity grows approximately 2 percent more quickly than productivity for U.S. industry as a whole. This conclusion is confirmed over every time period tested from the recent and relatively short time period covered by the latest Christensen direct study of TFP to the longest time period considered, 1929-1993, in an indirect study. Based on these historical comparisons of TFP growth between the telecommunications industry and the U.S. as a whole, the productivity differential for a price cap formula has thus averaged about 2 percent. That is, if telephone industry prices had grown at approximately 2 percentage points more slowly than the overall rate of inflation, then telephone prices would have been growing at about the same rate as telephone costs.

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U.S. TFP 10 Year Moving Average
Generally Varies Between 1 and 3 Percent

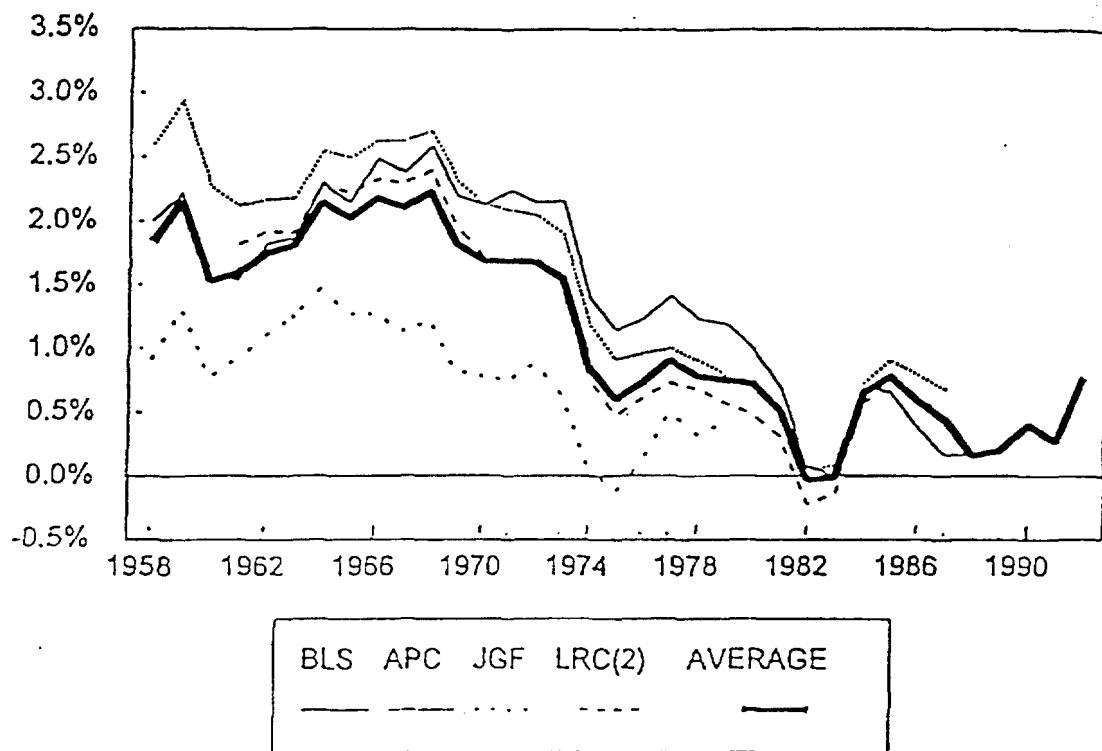


Figure B.2
Telecommunications TFP 10 Year Moving Average
Generally Varies Between 2 and 5 Percent

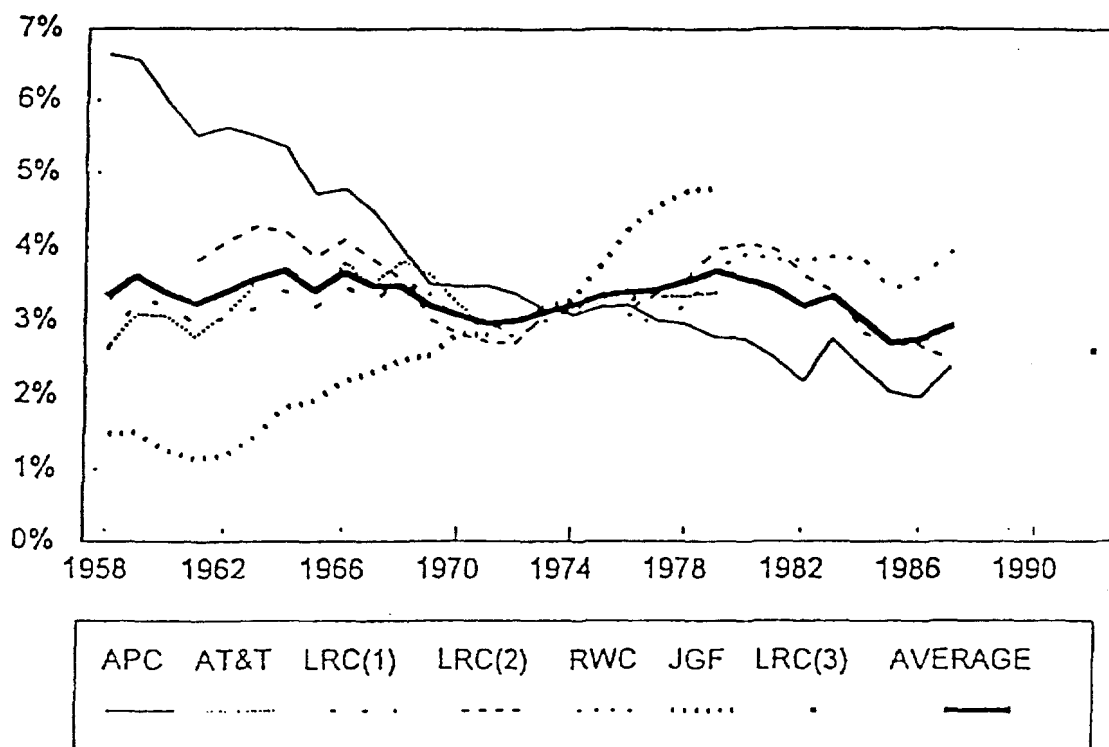


Figure B.3
Telecom TFP 10 Year Moving Average Minus
U.S. TFP 10 Year Moving Average Varies Between 1 and 3 Percent

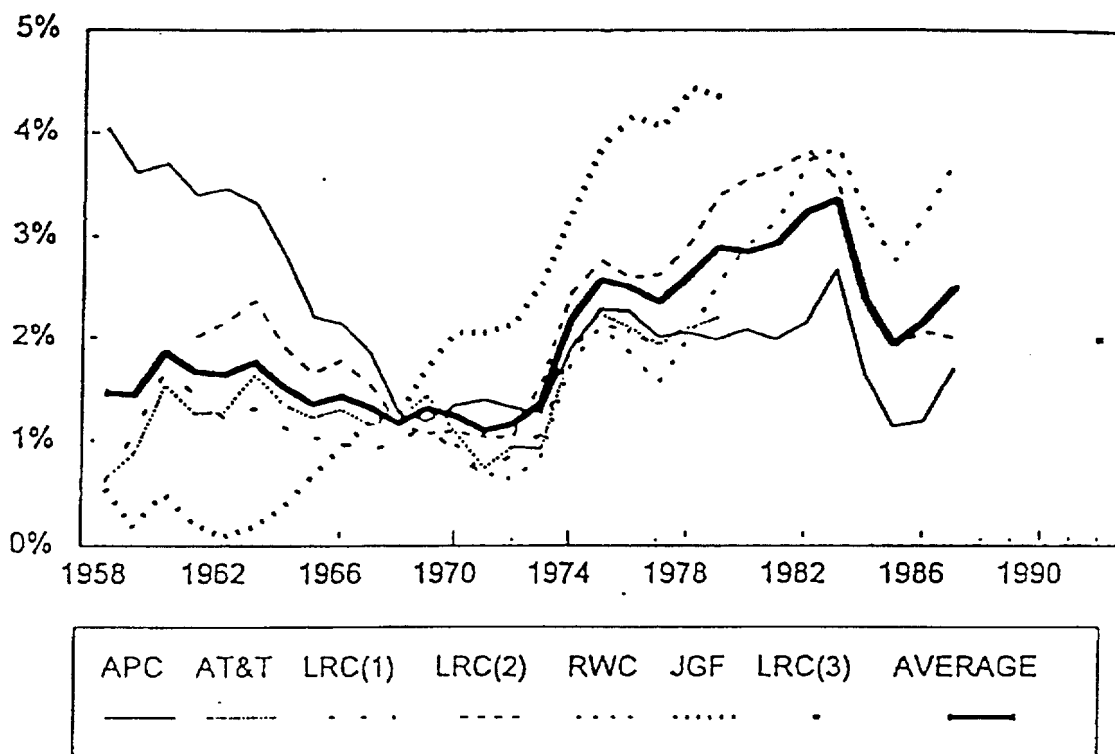


Figure B.4
Long Run Annual Productivity Offset
CPI-U All Commodities - CPI-U Total Telephone

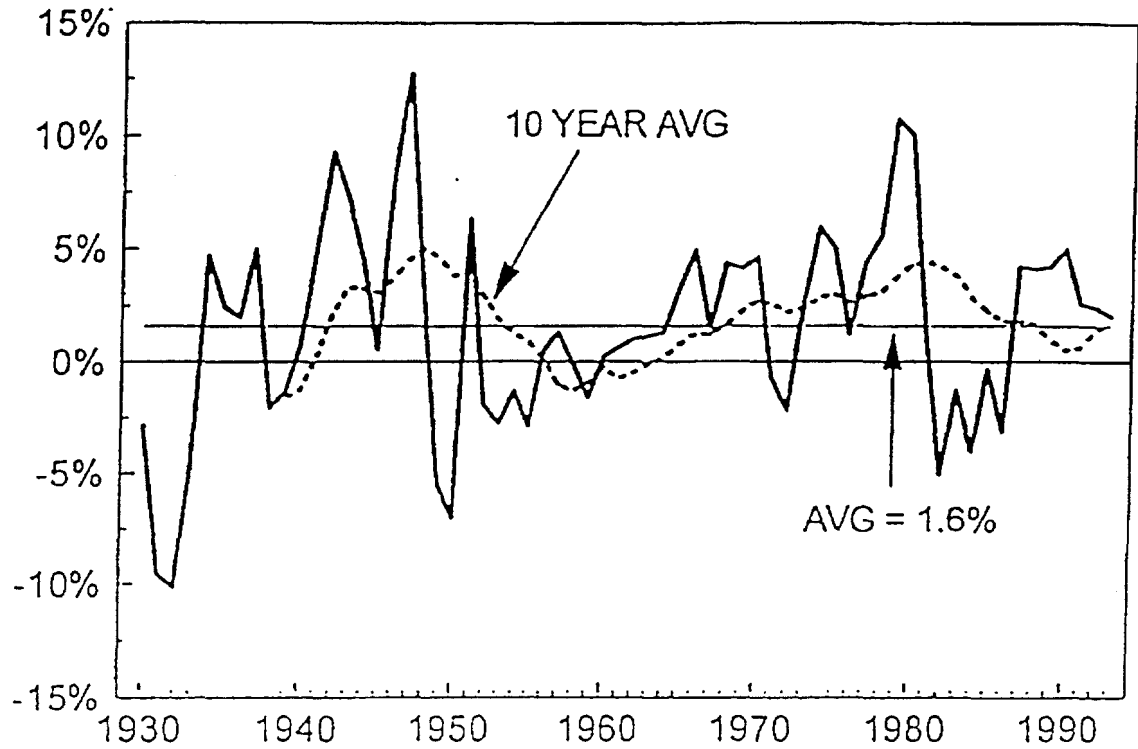


Figure B.5
Long Run Productivity Offset
GNP-PI - CPI-U Total Telephone

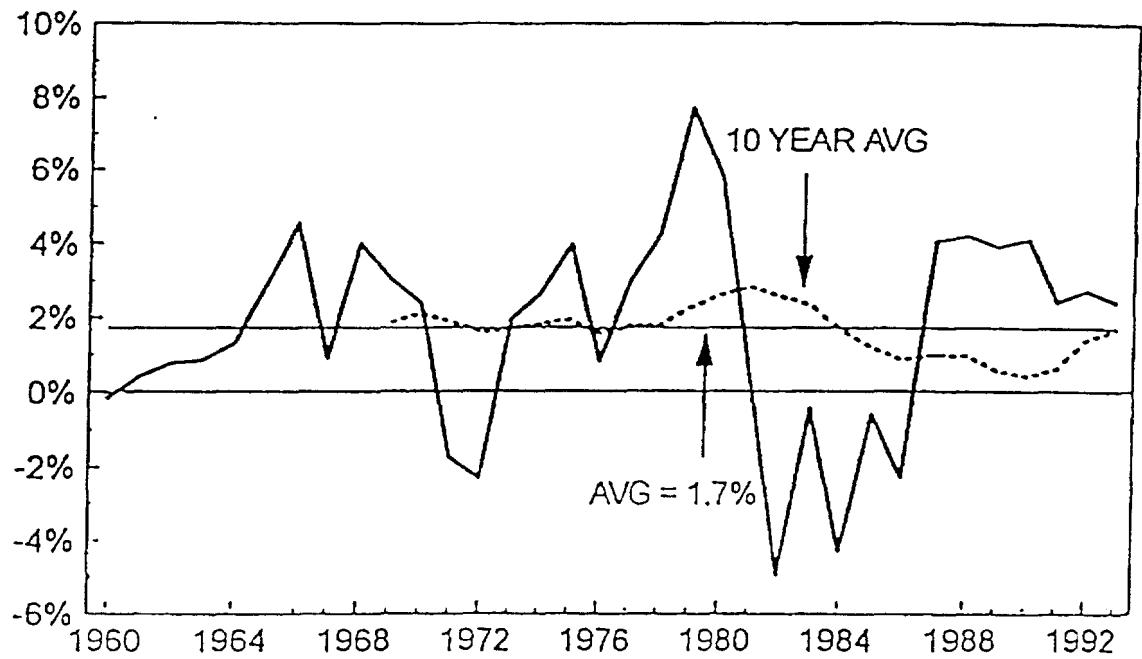


Figure B.6
Long Run Productivity Offsets
for Local Telephone Companies

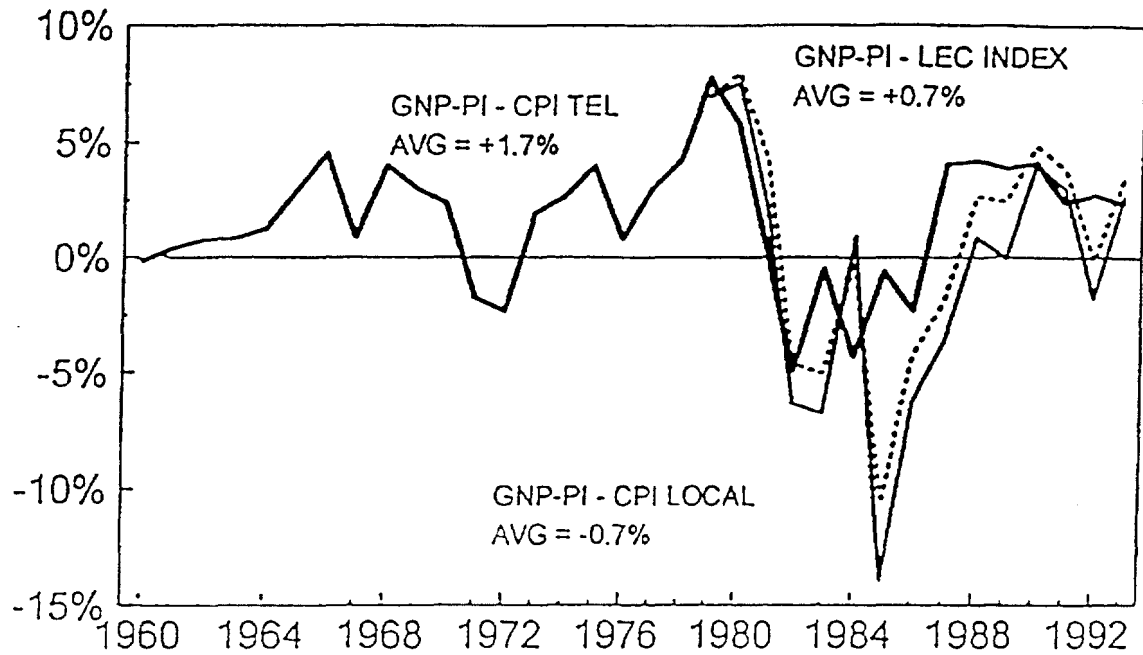


Figure B.7
U.S. Private Business TFP Growth

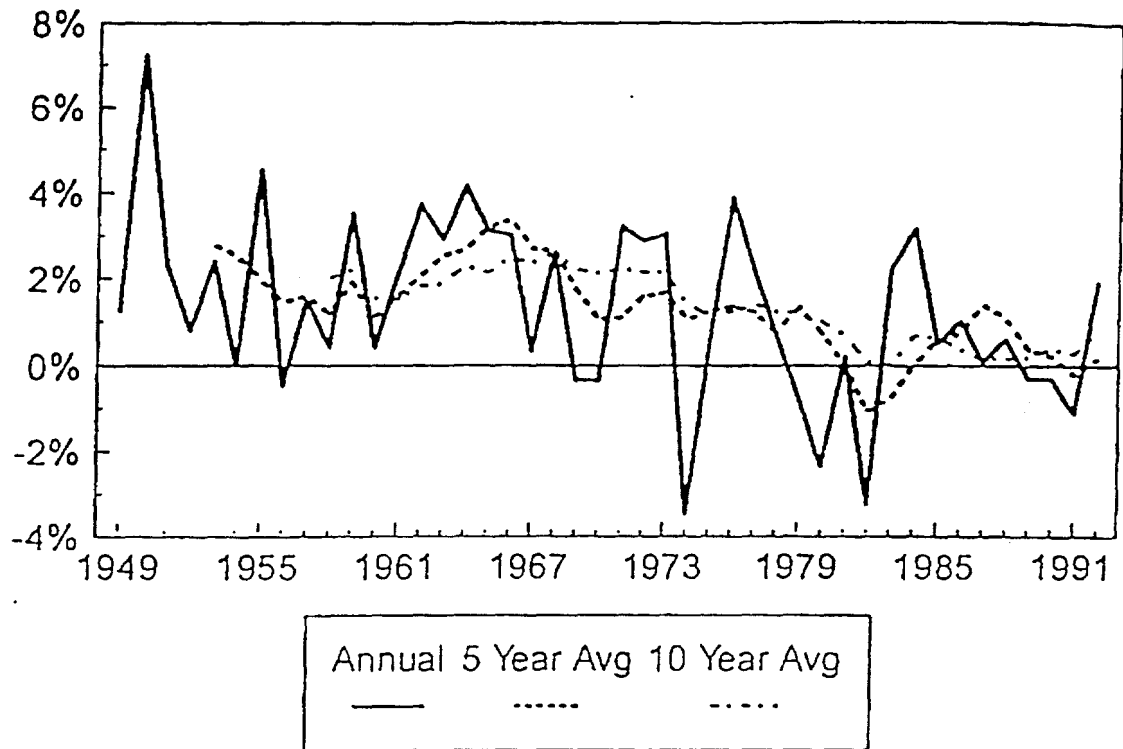


Figure B.8
Telecommunications Industry TFP Growth

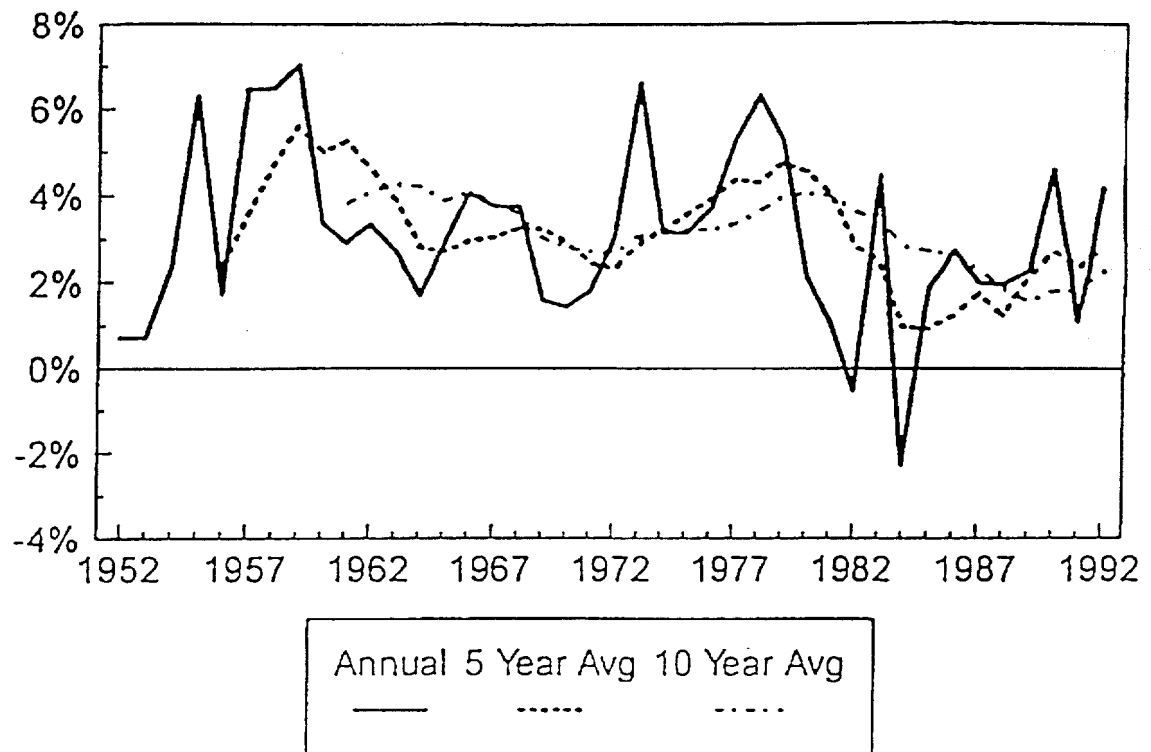
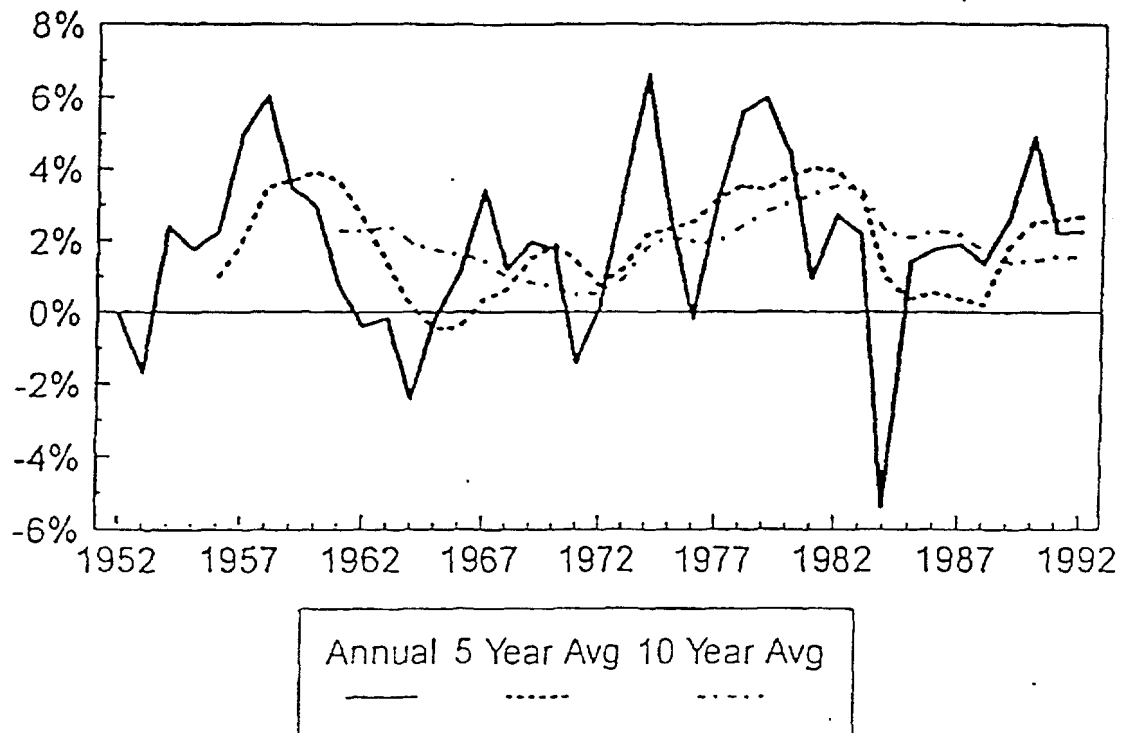


Figure B.9
Differences in Annual TFP Growth
Telecommunications - U.S. Private Business



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